

Exercises for group work

Exercises for focusing on important aspects of today's topics:

Q1. Explain why chromosomes are X-shaped during the metaphase of mitosis (just before the chromatids are separated during the anaphase).

The chromosomes each consist of two sister chromatids held together by cohesin-proteins in the centromeres, which makes the chromosomes appear as an X.

Q2. What is the purpose of the cell membrane disintegrating during mitosis?

This is to allow the chromosomes to be transported to the poles. The centromeres are located outside the nucleus and microtubuli must reach in from the centrosomes and connect to the kinetochores of the chromosomes.

Q3. Explain how the chromatids are transported to the poles of the cell during mitosis.

The transport of the chromatids to the poles occurs via microtubuli that originate from the centrosomes (located at the poles) and ends in the kinetochores of the chromosome's centromeres. Depolymerization of the microtubuli and the motor protein dynein in the kinetochores both add to the movement of the chromatids towards the poles.

Q4. What is the purpose of the cyclins during the mitotic cell cycle?

They control the transition between the different phases (G1-> S -> G2 -> M) making sure that the cell divides in a restricted manner.

Q5. What would happen to future offspring, if both copies of a chromosome by mistake were transported to the same pole during the first meiotic cell division?

Different mistakes can occur and most of them will lead to the death of the fetus. A few combinations lead to live individuals, who suffer from various complications. As an example, three copies of chromosome no. 21 will lead to individuals with Down's syndrome, while the genotype X0 leads to Turner syndrome and XXY to Klinefelter syndrome.

Q6. In which two ways can a cell end its life? And what is the cause of each of the two ways?

- 1) *Necrosis: The cell dies in an uncontrolled manner due to, e.g., starvation, lack of oxygen or poison.*

- 2) *Apoptosis: Programmed, controlled cell death. The cell receives a signal from its environment that it should commit suicide for the good of the organism. Is very common during development of the fetus or if the cell is infected by virus.*

Q7. Why are bacteria not able to perform meiotic cell division?

Bacteria do not have homologous chromosomes as eukaryotic cells. Accordingly they cannot produce offspring with recombined chromatids.

Q8. What is the purpose of mitosis?

To produce two daughter cells that is genetically identical to the mother cell.

Q9. What is the purpose of meiosis?

To produce daughter cells (four from one mother cell) that is genetically different from the mother cell. This is achieved by the process of recombination (crossing-over) and two successive cell divisions.

Q10. What are histones and what is their function?

Histones are proteins around which DNA is coiled in eukaryotic cells. Their function is to condense the DNA so that it takes up less space in the nucleus. The condensation happens in a way so that each region can be made accessible when needed.

Q11: What is the difference between a cancerous cell and a normal cell?

Most importantly, a cancerous cell divides in an unrestrained manner and without having received a signal from the environment to do so. Furthermore cancerous cells can leave the tissue from which they have originated and move to another tissue type (metastasis). Morphologically (the way they look), cancerous cells have a higher nucleus-to-cytoplasm ratio due to the many cell divisions.

Q12. What is the difference between an oncogene and a tumour suppressor?

An oncogene is a gene that encodes a protein that induces cell division. Mutated oncogenes lead to increased cell division and possibly cancer via gain-of-function. A tumor suppressor is a gene that encodes a protein that restricts cell division. Mutated tumor suppressors lead to increased cell division and possibly cancer via loss-of-function. .

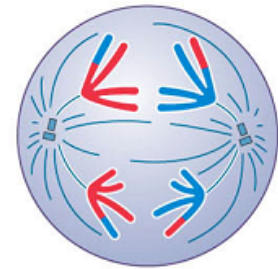
Q13. What is the difference between haploid and diploid cells?

Haploid cells contain a set of chromosomes in which each chromosome is only found in one copy, n . In contrast, diploid cells contain a set of chromosomes in which each chromosome is found in two copies, $2n$. In humans, gametes are haploid while somatic cells are diploid.

Q14. How does cytokinesis differ in plant versus animal cells? (Use a sketch to describe it if you like).

In animal cells a contractile ring of actin and myosin pinches the cell in two. In plant cells membranous vesicles appear along the plane of cell division and fuse to form a cell plate that separates the cell in two.

Q15. What is the name of the process that is shown schematically in the figure to the right? What just happened and what will happen next?



The process depicted in the figure is anaphase I of meiosis, where the homologous chromosomes are being separated. (Since each chromosome consists of two sister chromatids, you can tell that it is not anaphase II of meiosis or anaphase of mitosis). Previously, the homologous chromosomes have aligned in the equatorial plane of the cell and crossing-over has occurred (metaphase I). Next, the chromosomes gather into two new nuclei in telophase I.

Typical exam questions (all written material is permitted at the exam).

Q16 (1 point). What would be the consequence of genetic recombination between the sister chromatids during mitosis?

It would have no consequence, since the two sister chromatids are identical. One is generated by the replication process as a copy of the other.

Q17 (1 point). Are the chromosomes of a liver cell different than the chromosomes of a brain cell? (Explain your reasoning).

No, all somatic cells of a person contain the same chromosomes. Gametes, on the other hand, are haploid with only one copy of each chromosome.

Q18 (1 point). Is one of chromosome no. 12 from an individual identical to chromosome no. 12 from the individual's mother? (Explain your reasoning).

One of the chromosomes of any individual originates from the mother, while the other originates from the father. Due to the crossing-over process (recombination) during meiosis, none of the chromosomes are, however, totally identical to the chromosomes of the mother or the father.

Q19 (1 point). The daughter cells are identical to the mother cell after (mark the correct answer(s)):

- a) Binary fission
- b) Mitosis
- c) Meiosis

a and b.

Q20 (3 point, please note – this was an exam question in the fall of 2010 and very few students received full points for their answer. In particular many students had problems answering question b.)

In aneuploid cells, the number of chromosomes deviates from the norm. A cytological examination is made of a person, who is phenotypically a man. As it turns out, the person has two copies of each of the autosomal chromosomes, two Y chromosomes and one X chromosome.

a. Are the cells aneuploid? If yes, how do the number of chromosomes deviate from normal cells?

Yes, the cells are aneuploid. Normal cells of a man would indeed have two copies of each of the autosomal chromosomes, but only one Y chromosome and one X chromosome. The described man has one Y too many.

b. Explain (using a sketch if you like) how cells with this number of chromosomes have arisen (assume that *all* cells of the man contain the number of chromosomes described above).

See sketch on the next page

X chromosome
consisting of two
sister chromatids

Y chromosome consisting of two
sister chromatids

Meiose I

Meiose II

Non-disjunction, the two
sister chromatids of the Y
chromosome do not
separate during meiosis II

If this sperm cell
fuses with an egg
cell, the resulting
zygote will be YYX

